TEK **Installation/User**

Part No. 070-7052-00
Product Group 47

THE SD-24

TDR/SAMPLING HEAD

Please check for CHANGE INFORMATION at the rear of this manual.

Tektronix®
COMMITTED TO EXCELLENCE

T

U

V

I

L

O

R

S

Introduction

The SD-24 TDR/Sampling Head is a high-performance sampling head that can be installed in the 11800 series of Digital Sampling Oscilloscopes and in the SM-11 Multi-Channel Unit.

The SD-24 TDR/Sampling Head provides the following features:

- Two independent channels with signal acquisition and step generator capabilities. In addition to signal sampling, the two channels let you perform differential and common mode TDR and TDT measurements.
- Both step generators have switchable polarity, with 250 mV amplitude.
- A 28 ps typical displayed TDR incident rise time and a 17.5 ps or less acquisition risetime. The reflected rise time is 35 ps or less.
- A 20 GHz typical bandwidth provides high speed signal capture.
- For (SN B020652 and above) the measurement limit for noise is 750 µV rms typical without smoothing and 350 µV typical with smoothing on.
- For (SN B010651 and below) the measurement limit for noise is 1.3 mV rms typical without smoothing and 600 µV typical with smoothing on.
- Precision 3.5 mm connectors
- A Channel Select button that provides quick trace acquisition and selection from the sampling head front panel.

Index

A

B

C

D

E

F

As shown in the diagram, the SD-24 has two independent channels; each has its own acquisition and step generation circuitry. The strobe drive signal from the mainframe controls the timing of the strobe assertion to each acquisition system. The strobe generator in the sampling head is common to both channels, guaranteeing sampling coincidence between the two channels.

The strobe sense signal is a part of the strobe signal returned to the mainframe. The mainframe monitors the time duration of the strobe drive/strobe sense loop and adjusts a delay line (inside the mainframe) to maintain correct strobe timing.

Both channels have a step generator. The step generators can assert a negative-going or positive-going step independently. Using both channels, you can perform differential and common mode Time Domain Reflectometry (TDR) and two-port, time-domain network analysis.

The acquisition risetime is 17.5 ps or less. The displayed TDR reflected risetime is 35 ps or less. To ensure proper timing between the two step outputs, the second channel is equipped with a variable delay.

Glossary

Time-Domain Reflectometry (TDR)
A method of characterizing a transmission line or network by transmitting a signal from one end and monitoring the electrical reflections.

Time Domain Transmission (TDT)
A method of characterizing a transmission line or network by transmitting a signal through the network and monitoring the output.

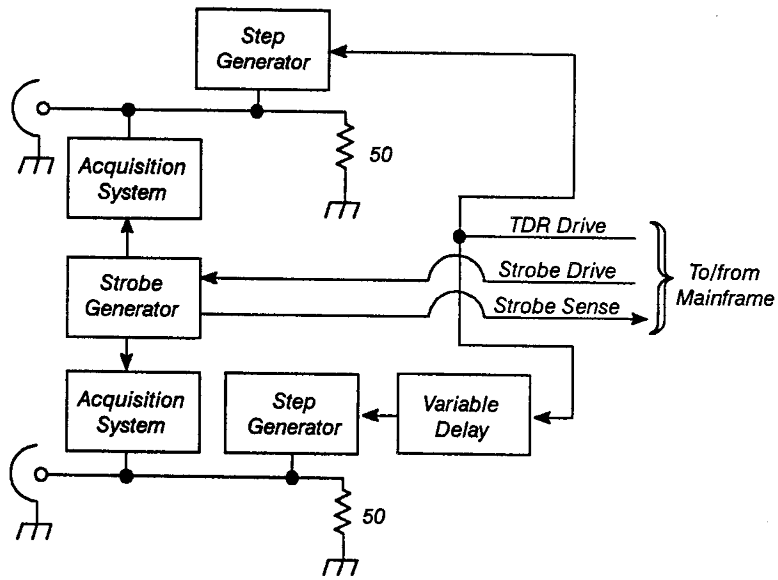
Differential Mode
A method of signal transmission where the true signal and its' logical compliment are transmitted over a pair of conductors.

Common Mode
A circumstance where a signal is induced in phase on both sides of a differential network.

Incident Pulse
When making TDR measurements, the initial transmitted pulse on a single conductor.

Reflected Pulse
When making TDR measurements, the pulse returned due to the reflection of the incident pulse, due to a mismatch in impedance.

Rho (ρ)
When making TDR measurements, the ratio of the incident pulse over the reflected pulse. A value of one (1) indicates complete reflection.



SD-24 Sampling Head Block Diagram

Environmental and Mechanical Specifications

Characteristic	Specification
Weight	314 grams (11 oz)
Height	71.05 mm (2.9 in)
Width	23.28 mm (0.95 in)
Depth	91.39 mm (3.8 in)
Ambient Temperature	
Operating	0° to 50°C (32° to 122°F)
Non-operating	-40° to 75°C (-40° to 167°F)
Altitude	
Operating	to 4.5 km (15,000 feet)
Non-operating	to 15 km (50,000 feet)
Humidity	to 95% relative humidity at up to 50°C (122°F)
MilSpec	Meets Mil-T-2800C, Type III, Class 5
Electromagnetic Compatibility	
United States	Mil-Std-461B: CE-03 Pt 4 Curve 1, CS-01 Pt 7, CS-02 Pt 4, CS-06 Pt 5, RE-02 Pt 7, RS-01 Pt 4 RS-02 Pt 5, RS-03 Pt 7 (limited to 1 GHz)
Germany	Meets VDE 0871/6.78 Class B

Safety

Terms in Manuals

CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.

WARNING statements identify conditions or practices that could result in personal injury or loss of life.

Terms on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

Symbols in Manuals

Static Sensitive Devices

Symbols on Equipment

DANGER
High Voltage

Protective
ground (earth)
terminal

ATTENTION
Refer to
manual

Step Generator Electrical Specifications

Characteristic	Specification
Maximum Repetition Rate	200 KHz
Output Amplitude	±250 mV
Channel 2 Delay Adjustment	±50 ps typical relative to channel 1
Insertion Delay Stability	
One Channel	±1 ps/°C
Between Channels	±0.2 ps/°C

TDR Electrical Specifications

Characteristic	Specification
Displayed Risetime	
Incident	28 ps typical, 10% to 90%, at +250 mV or -250mV output
Reflected	35 ps or less, 10% to 90%, at +250 mV or -250mV output
Maximum Repetition Rate	200 KHz
Incident Aberrations at +250 mV or -250 mV	
10 ns to 20 ps before step	±3% or less
<300 ps after step	+10%, -5% or less, typical
300 ps to 5 ns after step	±3% or less
5 ns to 100 ns	±1% or less
elsewhere	±0.5% or less

Grounding the Instrument

The SD-24 is grounded through the mainframe instrument that it is installed in. To avoid electric shock, make sure that the mainframe instrument is plugged into a properly wired receptacle where earth ground has been verified by a qualified service person. Without the protective ground, all parts of the mainframe instrument and the sampling head are shock hazards. This includes knobs and controls that may appear to be insulators.

Do Not Operate in Explosive Atmospheres

The SD-24 provides no explosion protection from static discharges or arcing components. Do not operate the instrument in an atmosphere of explosive gases.

Specifications

Acquisition Electrical Specifications

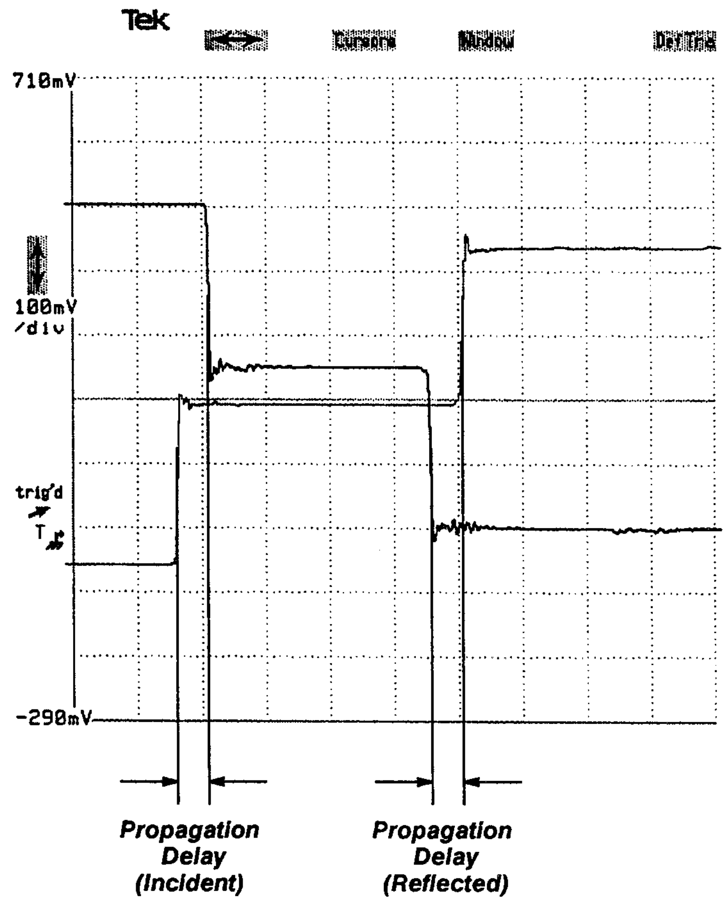
Characteristic	Specification
Bandwidth	20 GHz typical
Sampling Repetition Rate	
Maximum	200 kHz
1.3 Minimum	100 Hz
Risetime	17.5 ps or less, 10% to 90%
Aberrations	
10 ns to 20 ps before step	±3% or less, typical
<300 ps after step	+10%, -5% or less, typical
300 ps to 5 ns after step	±3% or less, typical
5 ns to 100 ns	±1% or less, typical
elsewhere	±0.5% or less, typical
Maximum Safe Input Signal Voltage	±3 V
Maximum Operating Input	1.6 V p-p (AC plus offset)
Maximum Signal Voltage	1.0 V p-p
Dot Transient Response	
accuracy after calibration at operating temperature	±5% for signals up to 0.5 V p-p
Adjustment Range	Adjustable to unity for signals up to 1.0 V p-p
Displayed Noise	
Unity Dot Response	(SN B020652 and above) 1.2 mV max, 750 µV typical (SN B010651 and below) 1.3 mV rms typical
With Smoothing	(SN B020652 and above) 550 µV max, 350 µV typical (SN B010651 and below) <0.6 mV rms typical
Input Termination Impedance	50 ± 0.5Ω
Isolation Between Channels	
≤ 1% p-p voltage transmission from channel driven with 067-1338-00 to quiescent channel	
Time Coincidence Between Channels	
Accuracy	10 ps
Stability	<0.2 ps/°C

Electro-Static Discharge

Acquisition circuitry in the sampling heads is very susceptible to damage from electrostatic discharge and from overdrive signals and DC voltages. Be sure to operate the mainframe instrument only in a static-controlled environment. Be sure to discharge to ground any electrostatic charge that may be present on cables before attaching the cable to the sampling head.

Whenever you remove a sampling head from the instrument, install shorts on the sampling head connectors. Be sure to store the head in a static-free container, preferably the shipping container. Whenever you move the sampling head from one instrument to another, use a static-free container to carry the head.

Be sure to follow the precautions described in the manuals accompanying your mainframe instrument, to guard against electro-static damage to the mainframe and sampling heads.



TDR Propagation Delay

Connector Care

The front of the sampling head has two precision 3.5 mm connectors, one for each channel. They are for attaching the signal cable or the device under test. These are high-precision connectors with a closer mechanical tolerance than standard SMA cables. Never attach a cable to a sampling head connector if the cable has a worn or damaged connector: damage may result.

Use extra care when attaching or removing a cable from the connectors. Turn only the nut, not the cable. When attaching a cable to a sampling head connector, align the connectors carefully before turning the nut. Use light finger pressure to make this initial connection. Then tighten the nut lightly with a wrench.

For best repeatability and to prolong the life of both connectors, use a torque wrench and tighten the connection to the range of 7–10 lb-in (79–112 N-cm).

If the sampling head connectors will receive heavy use, such as in a production environment, you should use an adapater (such a connector saver) installed on the sampling head connector to make connection to the device under test.

TDT Measurements

You can make forward and reverse Time Domain Transmission (TDT) measurements using the SD-24. To perform a TDT measurement, connect one sampling head channel to the input of the device under test and the other sampling head channel to the output of the device under test. You can then alternately enable the step generators on both channels and sample the transmitted signal on the other channel to perform forward and reverse TDT measurements.

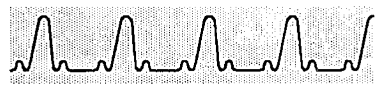
More About TDR Measurements

When making differential or common mode TDR measurements, it is important that the two steps arrive at the same time at the reference plane (usually the connection point to the device under test). To check and adjust this condition, disconnect the transmission cables from device under test *at the point where the cables connect to the device*. Then adjust the TDR step delay for the second channel, so that the propagation delay between the incident edges is equal to the propagation delay between the reflected edges, as shown in the illustration.

For some measurements and comparisons, you may want to visually line up the leading edges of both TDR steps, even though you've delayed the step assertion time for one channel. To do this, create a window of each trace, and place each window trace in the lower graticule. Then select one of the window traces and, using the ↕ icon and the lower knob, position the leading edge of the trace. This does not affect the arrival of the TDR steps at the reference plane.

See the *11801* or *11802 User Reference* manual for more information about windows.

Installing the SD-24



The SD-24 TDR/Sampling Head fits into the front panel of a compatible instrument, such as the 11801 Digital Sampling Oscilloscope. The figure below shows the front panel of the 11801 Digital Sampling Oscilloscope, and the locations of the sampling head compartments.

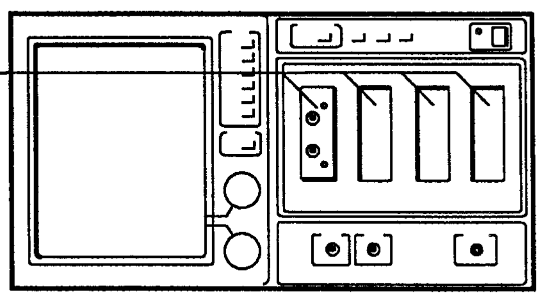
At least one sampling head must be installed in an 11801 or similar instrument for the instrument to sample signals.

CAUTION

Never install or remove a sampling head when mainframe power is on.

To install a sampling head, first power-off the instrument. Then place the sampling head in a compartment and slowly push it in with firm pressure. Once the head is seated, turn the screw shaft on the sampling head to tighten the head into place.

Sampling Head Compartments



Sampling Head Compartments in 11801 Digital Sampling Oscilloscope

Note that both steps are positive. This is equivalent to common mode transmission. For both traces, common mode operation appears as though the cable is open at the middle (since the two steps meet and are cumulative).

☐ Step 6: Turn either knob on the mainframe to adjust the delay for channel 2. This varies the time when channel 2 asserts the TDR step.

Notice that on the upper trace the second edge moves horizontally, and on the lower trace the first edge moves horizontally. They are actually the same step, seen at different times by the two channels.

☐ Step 7: Press the **[WAVEFORM]** button. On the display, touch **[Sampling Head Fnc's]**. Touch **[1]** and the **[TDR Polarity]** selector. This causes channel 1 to assert a negative TDR step. Touch **[Exit]**.

Notice that the upper channel is asserting a negative TDR step. This is equivalent to differential TDR. Note that in both traces, the step appears as though the cable is shorted at the center of the cable (since the two steps meet and collapse to zero volts).

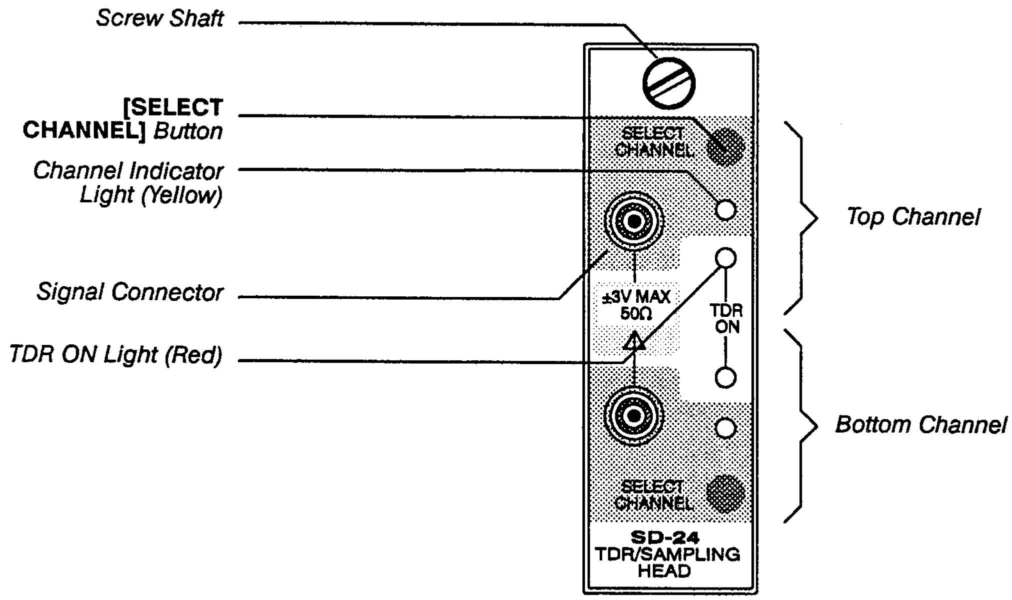
When the TDR steps on the two channels are opposite (one positive and one negative), you can now define a trace that represents the true differential signal by touching the **[DefTra]** icon and touching **[Mainframe] [1] [-] [Mainframe [2] [Enter]**.

When the TDR steps on the two channels are the same polarity (both positive or negative), you can define a trace that represents the true common mode signal by touching the **[DefTra]** icon and touching **[Mainframe] [1] [+] [Mainframe [2] [Enter]**.

Using the SD-24

Front Panel

The figure below shows the front panel of the SD-24 TDR/Sampling Head and identifies the buttons, lights and connectors.

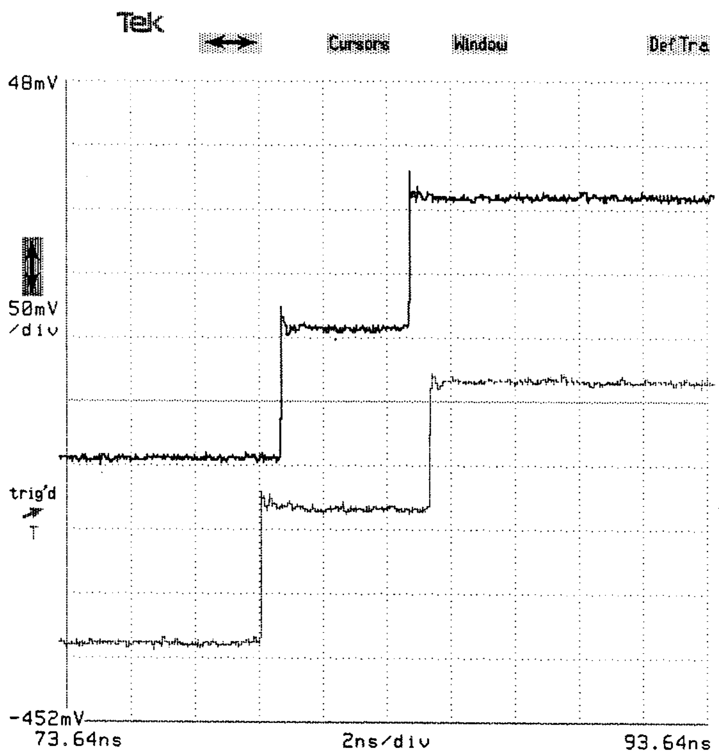


Sampling Head Control Panel (SD-24 shown)

Each channel has a 3.5 mm connector for signal input/step output, a **SELECT CHANNEL** button and a yellow channel indicator light.

CAUTION
Applying a voltage outside the range ±3 V can result in damage. Static electricity is a hazard.

The input diodes used in the sampling heads are very susceptible to damage from overdrive signal or DC voltages, and from electrostatic discharge. Never apply a voltage outside the range of ±3 V. Operate the instrument only in a static-controlled environment.



Channels 1 and 2 TDR

Notice that there are two rising edges on each trace. On the upper trace, the left-most edge is the step transmitted by the step generator of the upper channel, M1. The second rising edge is the step transmitted by the step generator of lower channel, M2.

On the lower trace, the left-most edge is the step transmitted by the step generator of the lower channel, M2. The second rising edge is the step transmitted by the step generator or the upper channel, M1.

Connecting Signals

The signal connector for each channel is used to connect signals to be sampled, and to output TDR steps. These are precision 3.5 mm connectors, which are mechanically compatible with the SMA standard. Input impedance is 50 Ω.

Use extra care with the sampling head connectors. See the section titled Connector Care.

Button and Lights

Each channel has a **SELECT CHANNEL** button, a yellow channel light, and a red **TDR ON** light.

The yellow channel light can have three states: off, on steady, or blinking. The operation of the channel button depends on the state of the light:

- If the yellow light is off, then the channel is not acquiring trace data, and no trace is displayed from that channel. When the light is off, pressing the **SELECT CHANNEL** button causes the channel to acquire trace data and display a trace of that channel. Input from that channel becomes the selected trace, so the yellow light blinks.

- If the yellow light is on steady, the channel is acquiring trace data. The trace data is displayed as a single trace and/or may be part of another displayed trace. However, the trace is not the selected trace. When the light is on steady, pressing the **SELECT CHANNEL** button selects that trace, causing the light to blink.

- If the yellow light is blinking, the channel is part or all of the selected trace. When the light is blinking, pressing the button removes *all* traces displaying that channel. The channel stops acquisitions and the yellow light turns off.

The red **TDR ON** light indicates whether or not the SD-24 is sending out a step from the step generator through the signal connector.

☐ Step 4: Press the **[SELECT CHANNEL]** button for the lower channel on the sampling head. Adjust the vertical and horizontal settings to display the TDR step asserted by the upper channel.

The horizontal distance separating the leading edges on the two traces is the time it takes the step transmitted by channel 1 (upper channel) to be sampled by channel 2 (lower channel).

☐ Step 5: Touch **[Mainframe]**, and **[2]**. Touch **[TDR]** to turn on the step generator for that channel. The lower channel on each sampling head has an internal delay adjustment. This lets you set the time at which the step generator for the lower channel asserts the TDR step. Touch the **[TDR Head Δ Delay]** selector. Then touch **[Exit]** to remove the pop-up menu.

In step 8, you turned on TDR for the lower channel, and you also assigned the knobs to adjust delay for the TDR step generator. The mainframe displays the following two traces.

You cannot control the TDR function from the SD-24 front panel; the mainframe instrument turns this feature on or off. The next section covers mainframe control of the sampling head.

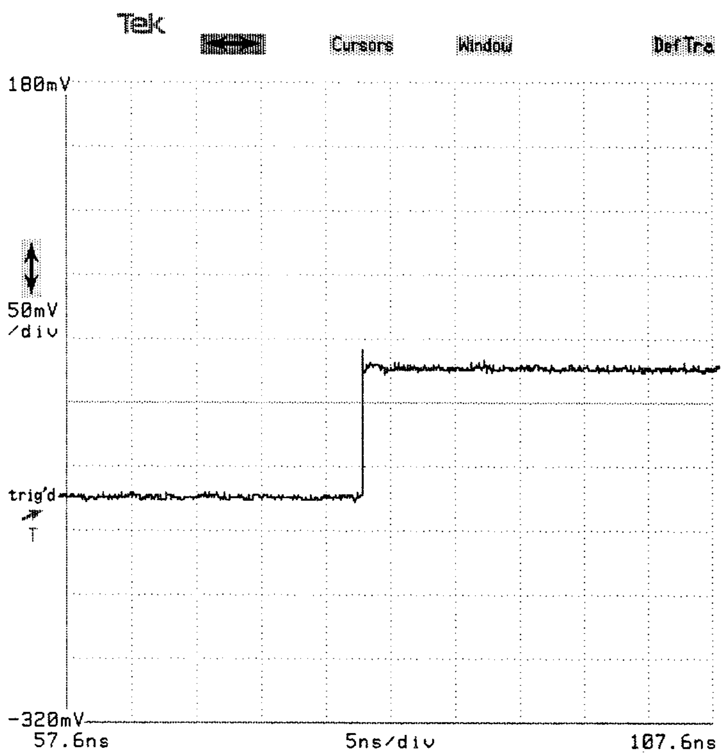
Mainframe Control of the SD-24

The SD-24 TDR/Sampling Head is a part of a larger instrument system. Most of the SD-24 functions are controlled automatically by the mainframe instrument. These include such things as vertical scaling and horizontal sampling rate. You do not directly control these parameters, but they are controlled for you as you perform tasks on the mainframe. There are other parameters you can control from the SD-24 front panel. These were covered in the last section.

There are additional SD-24 functions that you control directly, but from the mainframe instrument. These functions are:

Turning smoothing on or off on one channel affects both SD-24 channels.

- Smoothing – when enabled, reduces noise in the signal before it is digitized.
- TDR – when enabled, turns on the step generator and sends a step out the signal connector. This step is synchronized with the internal clock of the mainframe.
- TDR Polarity – determines whether the TDR step is negative-going or positive-going.
- TDR Head ΔDelay – adjusts the time delay of the channel 2 TDR step (lower channel) with respect to the channel 1 TDR step (upper channel).



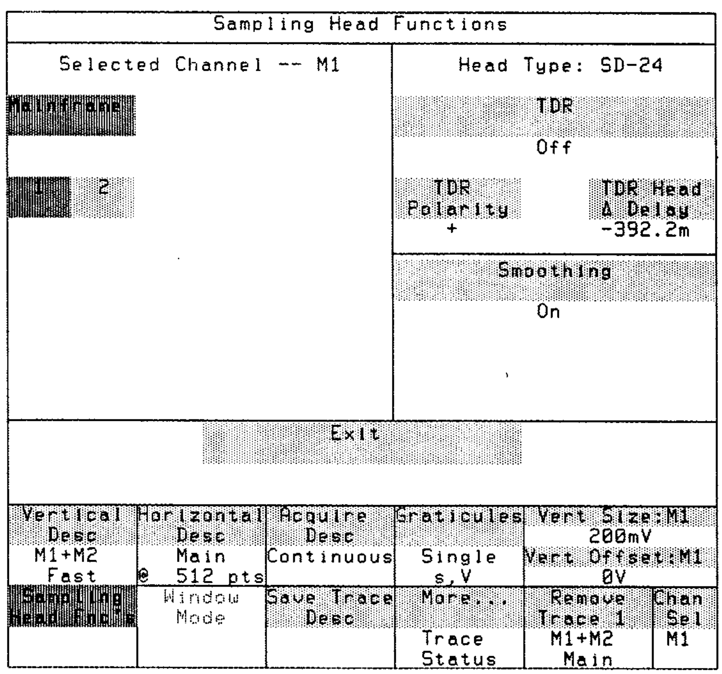
Single Channel TDR

In the above figure, notice that there is only one rising edge, that of the incidentTDR step. There is very little or no reflection, because the impedance of the termination in the receiving channel connector matches the impedance of the cable.

Commands From the Mainframe Front Panel

The Waveform major menu lets you access the **[Sampling Head Fnc's]** pop-up menu. Both of these are shown in the next figure.

You first select the channel you want to set in the **Selected Channel** section of the pop-up menu. Touch the **[Smoothing]**, **[TDR]**, or **[TDR Polarity]** selectors to change those settings. Touch the **[TDR Head Δ Delay]** selector to assign the knobs to that parameter.



The **[Sampling Head Fnc's]** *Pop-Up Menu*

Example: Differential and Common Mode TDR

The SD-24 TDR/Sampling Head is able to perform differential and common mode TDR measurements. As described earlier, the sampling head has two sampling input channels and two independent step generators.

The step generator output for each channel is selectable for positive or negative polarity and amplitude. This example will show you how to use the two channels and step generators of the SD-24 to perform differential and common mode TDR measurements.

For this example you need an 11801 or an 11802 with at least one SD-24 installed in the left-most slot. You also need one SMA cable, preferably of 5 ns length. You can begin this procedure from where the previous procedure ended.

- ☐ Step 1: If you are starting this example from the previous example, perform steps 1 through 6 of the previous example.
- ☐ Step 2: Attach the loose end of the cable to the lower channel connector on the same sampling head.
- ☐ Step 3: Adjust the display size and position to show a trace similar to that shown in the figure on the next page:

Programmer Interface Commands

Commands from a remote computer to the 11801 or 11802 Digital Sampling Oscilloscope (via an IEEE-488 or RS-232-C interface) can control the several sampling head functions. These commands are described below.

For these commands, <alpha> indicates the channel number and <ui> indicates the unit number for the channel you want to affect.

- CH<alpha><ui> SMOOTHING:ON|OFF

  This command turns smoothing on or off.

- CH<alpha><ui> TDRSTATE:ON|OFF

  This command turns the TDR step generator on or off.

- CH<alpha><ui> TDRPOLARITY:PLUS|MINUS

  This command selects a negative-going or positive-going TDR step.

- CH<alpha><ui> TDRDELAY:<NRx>

  This command specifies the delay of the channel 2 step generator step (lower channel) relative to channel 1 (upper channel).

For complete information about how to use the SD-24 to display traces, see the appropriate mainframe user reference manual.

☐ Step 8: Touch **[Graticules]** in the major menu and **[Feet]** or **[Meters]** in the pop-up menu. If you know that the propagation velocity of your cable differs from the default, touch the **[Propagation Velocity]** selector and adjust this parameter. If you don't know the velocity or are using Tektronix SMA cables, accept the 0.7 default. This unitless number represents the fraction of the speed of light that signals pass through your network or transmission line.

Measurements and cursor readouts are always expressed in the same units as the graticule axes.

The horizontal axis is now calibrated in your chosen units of measurement.

To set the vertical axis to rho, you need to specify the amplitude, in volts, of the incident step that the sampling head sends through the cable. Touching the **[Reference Amplitude]** selector assigns both knobs to this parameter.

For the SD-24, this step amplitude is 250 mV. This amplitude is also the default setting of this parameter, so you don't need to change this parameter when using the SD-24.

☐ Step 9: Touch the **[Rho]** selector.

☐ Step 10: If you need to set the reference amplitude, touch the **[Reference Amplitude]** selector and use the knobs to set the desired value.

☐ Step 11: Touch **[Exit]** to remove the pop-up menu and view the trace and graticule.

The vertical axis is now displayed in rho.

Adjusting Parameters

To get the best performance from your SD-24 TDR/Sampling Head, you may need to adjust sampling head parameters. These parameters affect how the sampling head acquires signals and affect the accuracy of the resulting trace.

Typically, you may want to adjust sampling head parameters whenever you have moved the sampling head to another slot or if the ambient air temperature has changed more than 5°C since the parameters were last adjusted. At the factory, the parameters are set in an environment with an ambient air temperature of 25°C.

You should adjust sampling head parameters after a 20 minute warm-up.

You can adjust sampling head parameters at any time. However, during instrument warm-up, the values may change as the temperature varies. You should adjust the sampling head parameters after the instrument has been on for at least 20 minutes.

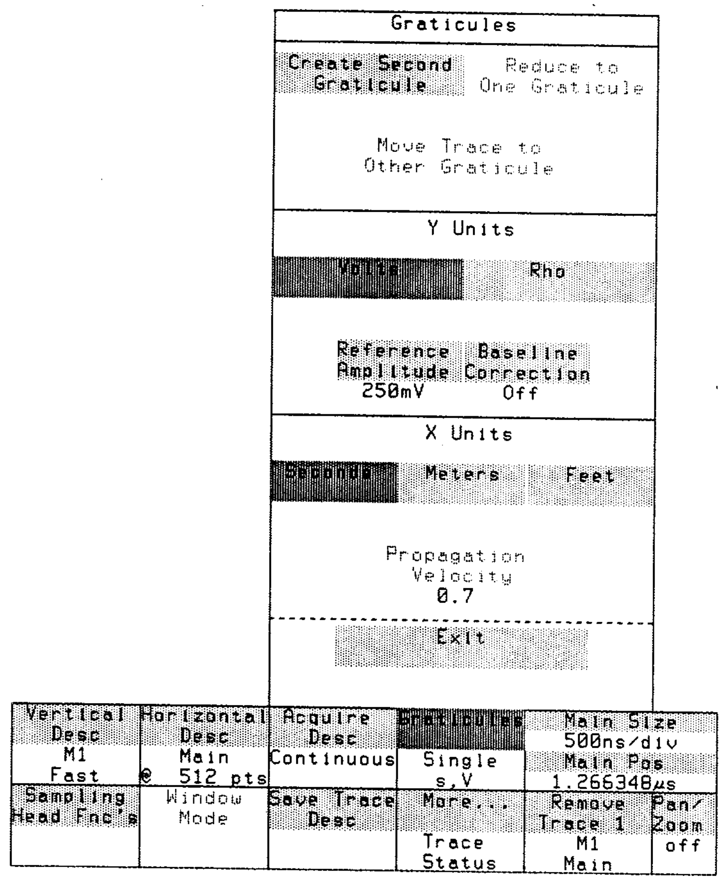
There are three different parameters that you can adjust on each channel of your sampling head.

- Loop gain
- Offset null
- TDR step amplitude

The actual procedure for performing the adjustment is dependent on the mainframe instrument. For the 11801 and 11802 Digital Sampling Oscilloscopes, you can use the Enhanced Accuracy feature to adjust sampling head parameters. It's a quick and simple process. See the appropriate instrument user's manual for instructions to perform these adjustments.

Stored Parameters

The SD-24 contains non-volatile memory that stores two values for each of the above parameters: the *factory default value* and the *user constant*. These values are *always* remembered in the sampling head, even if you remove the sampling head from the mainframe.



The **[Graticules]** *Pop-Up Menu*

The factory default values for the sampling head parameters are set at the factory. These default values are appropriate for many conditions.

If you decide to adjust a sampling head parameter, the parameter is immediately applied to the head, but is lost when you power-down the instrument. However, you can store the new parameter value as the user constant. The user constants are stored in EEPROM in the sampling head, so that they are not lost at power-down and are restored at power up.

If you initialize the 11801 or 11802 Digital Sampling Oscilloscope, the last-used values are applied to the sampling head.

If you are not sure of the current user value for a sampling head parameter, you can assign the user parameter value to equal the factory default value. The factory default value offers a reasonable parameter value for many conditions. See the *11801* or *11802 User's Reference* manual under Enhanced Accuracy for more information.

Loop Gain

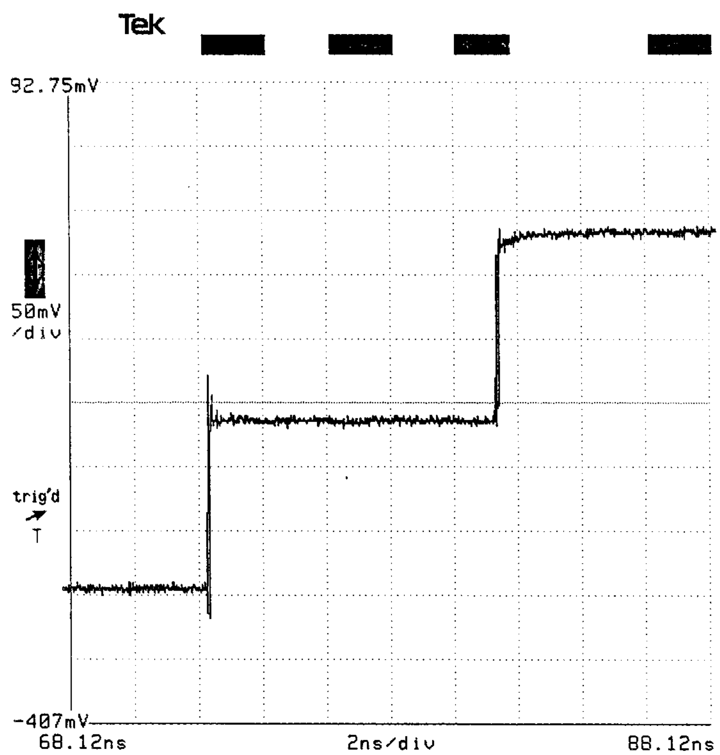
Loop gain determines the sampling head's ability to accurately follow an input voltage change that occurs between two adjacent samples. How accurately the sampling head output follows the input signal is termed the dot transient response.

When loop gain is unity (1) the first sample value acquired after an input voltage change accurately reflects the voltage change, indicating a good dot transient response. The figure on the next page shows this condition.

If loop gain is adjusted too low, then the value of first sample value acquired after an input voltage change will lie somewhere between the value of the last sample and the new voltage.

If loop gain is adjusted too high, then the value of the first sample acquired after the input voltage change will be greater than the new voltage level.

The following figure shows displayed trace results for the three loop gain conditions.

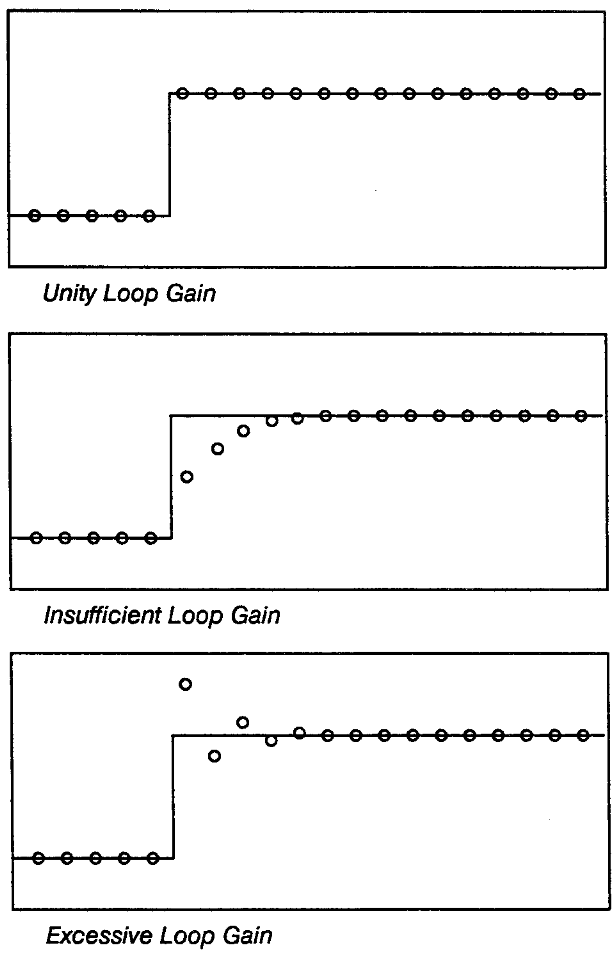


TDR Step and Reflection

The first rise of this trace is the incident TDR step leaving the sampling head; the second rise is the reflection of the step returning from the end of the cable.

Changing Graticule Units for TDR

The units of measure commonly used in TDR are units of rho (ρ), measured on the vertical axis, and time on the horizontal axis. You can change the measurements by using the **[Graticules]** selector on the Waveform major menu.



Displayed Trace with Three Loop Gain Settings

☐ Step 4: Press the **[SELECT CHANNEL]** button on the sampling head input channel to which you have connected the cable.

You will see a flat trace on the display because there is no signal on the channel. When the TDR feature is used, the sampling head supplies the signal for you. As with the calibrator signal, the TDR step is synchronized with the internal clock.

☐ Step 5: Press the **[WAVEFORM]** button, and touch the **[Sampling Head Fnc's]** selector.

☐ Step 6: Touch **[Mainframe]**, **[1]** (or whichever channel you are using) and then **[TDR]** to turn it on. Touch **[Exit]** to remove the pop-up menu.

The sampling head will turn on a red light next to the channel input connector, indicating that TDR is activated for that channel. TDR can be used on each channel independently.

Leave at least one division of baseline trace to the left of the first rise

☐ Step 7: Adjust the display sizes and positions to show a trace similar to that shown on the next page. **[AUTOSET]** may make this job easier, and the vertical (↕) and horizontal (↔) icons will let you make fine adjustments.

Adjusting Loop Gain

For the 11801 and 11802 Digital Sampling Oscilloscopes, you can adjust loop gain automatically or manually from the Enhanced Accuracy menu. If you prefer to adjust loop gain manually, the 11801 and 11802 also provide a divide-by-two feature. This feature is helpful if you are using the Calibrator signal or TDR signal generator output to adjust loop gain. You can also use the divide-by-two feature if you are using the trigger output of the mainframe to trigger an external generator.

You might consider adjusting the loop gain whenever you are sampling a trace that has peak-to-peak voltages and transition-speed characteristics that are substantially different from the previous trace. In this case, you can use the actual signal that you want to measure, and turn off vectoring so that you can see each sample individually.

For instructions to adjust the loop gain, see the appropriate mainframe user reference manual, under Enhanced Accuracy.

The SD-24 contains non-volatile memory that stores two values for the loop gain adjustment: the factory default value and the user value. These were discussed at the beginning of this section.

Offset Null

The offset null adjustment removes unwanted DC offset that may be present in the sampling head. This adjustment effectively "zeroes" the sampling head so that an input signal with 0 V of amplitude delivers a 0 V output.

If offset null is not adjusted correctly, measurements taken at the mainframe will be incorrect. The absolute voltage values for any cursors displayed on the trace will also be incorrect.

Adjusting Offset Null

For the 11801 and 11802 Digital Sampling Oscilloscopes, you can adjust offset null automatically or manually from the Enhanced Accuracy menu. If you prefer to adjust offset null manually, be sure to adjust the loop gain first.

Example: Taking TDR Measurements

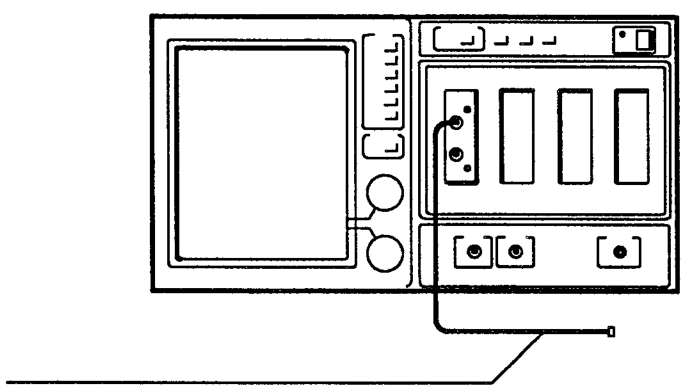
This example demonstrates the TDR (Time Domain Reflectometry) feature of the SD-24 sampling heads. TDR is a method of examining and measuring a network or transmission line by sending a step into the network and monitoring the reflections.

For this example you will need an 11801 or an 11802 with at least one SD-24 installed. Also, you will need one SMA cable, preferably of 5 ns length.

☐ Step 1: Initialize the 11801 (press **[UTILITY]** and touch **[Initialize]**).

☐ Step 2: Attach one end of the cable to any SD-24 sampling head input. Leave the other end unattached.

☐ Step 3: Press the **[TRIGGER]** button and touch **[Source]** and **[Internal Clock]**.



Connections for Example

You can adjust offset null by terminating the channel input connector with a 50-Ω terminator and adjusting the offset null (with the knob) so that the displayed "trace" is set to the 0 V position on the screen.

If you adjust offset null manually, the offset null setting is valid only for the current setting of the smoothing parameter (on or off).

For example, if smoothing is set to off and you adjust offset null manually, then if you turn smoothing on, the offset null value may not be valid. However, the SD-24 remembers the offset null values for when smoothing is on and off, so if you change the smoothing setting, the correct offset null value is applied.

If you adjust offset null automatically, using the Enhanced Accuracy menu, then the11801 and 11802 Digital Sampling Oscilloscopes adjust both offset null values (smoothing on and smoothing off).

Note that the SD-24 stores four offset null values: the two factory default values for when smoothing is on and smoothing is off, and the two user constants for when smoothing is on and when smoothing is off.

TDR Amplitude

The SD-24 has an internal step generator that is used with the acquisition channel to let you perform TDR measurements. You can adjust the amplitude of the TDR step.

The TDR step amplitude setting is highly stable and insensitive to temperature variations. You shouldn't need to adjust this parameter very often.

For the 11801 and 11802 Digital Sampling Oscilloscopes, you can adjust the TDR amplitude automatically or manually using the Enhanced Accuracy menu.

You can adjust the TDR step for a negative or positive polarity. With the channel output terminated by 50 Ω load, the TDR amplitude is adjustable from 0 to 250 mV, positive or negative. The repetition rate of the TDR step is set by the mainframe.

When the diode switch opens (reverse-biased), apparent resistance to ground at the acquisition point (and at the channel connector) is 25 Ω, because the internal circuit impedance is 50 Ω and the connector impedance is 50 Ω. This causes the acquisition point to rise to −250 mV.

The transition propagates to the open in the device under test and is reflected back to the acquisition point, causing the voltage at the acquisition point to rise to 0 mV. At the acquisition point, the time displayed from the first step to the second step is the propagation time from the acquisition point to the open in the device under test and back.

Baseline Correction

Baseline correction is a feature of the11801 and 11802 Digital Sampling Oscilloscopes. This feature holds the displayed baseline of a trace in one location despite variations of the offset in the sampling head. These offset variations are caused by changes in impedance at the device under test.

Baseline correction is especially useful with TDR/TDT measurements. Without baseline correction, changes in the DC resistance to ground for the cable or device under test would cause the entire step to move vertically on the display.

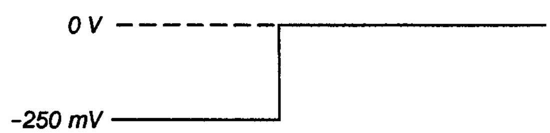
Baseline correction keeps the baseline in one location vertically. For the 11801 and 11802, you can enable baseline correction from the Graticules pop-up menu. For more information on baseline correction, see the *11801* or *11801 Digitial Sampling Oscilloscope User Reference* manual.

If you adjust the TDR step automatically, using the Enhanced Accuracy menu, then the11801 and 11802 Digital Sampling Oscilloscopes adjusts the amplitude for both the positive- and negative-going steps.

The SD-24 contains non-volatile memory that stores two values for the TDR amplitude adjustment: the factory default value and the user value. See Stored Parameters for more information.

Operation Into a 50 Ω Load

Initially, the diode switch is conducting. When the step generator output is connected to a 50 Ω load, the resistance to ground at the acquisition point is 25 Ω (because of the internal 50 Ω impedance). The 10 mA current source places −250 mV at the acquisition point.

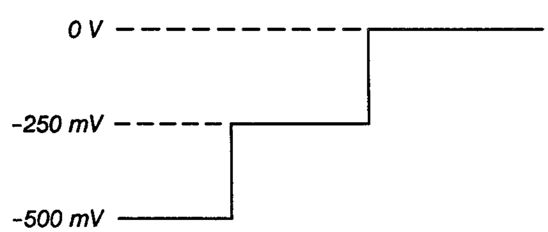


Step Generation with an 50 Ω Load

When the diode switch opens (reverse-biased), the return path to ground is broken and the acquisition point rises to 0 V. The matched impedance allows the acquisition point to remain at 0 V.

Operation Into an Open Circuit

Initially, the diode switch is conducting. When the step generator output is open, the resistance to ground at the acquisition point is 50 Ω (because of the internal 50 Ω impedance). The −10 mA current source places −500 mV at the acquisition point, as a starting condition.



Step Generation with an 50 Ω Load

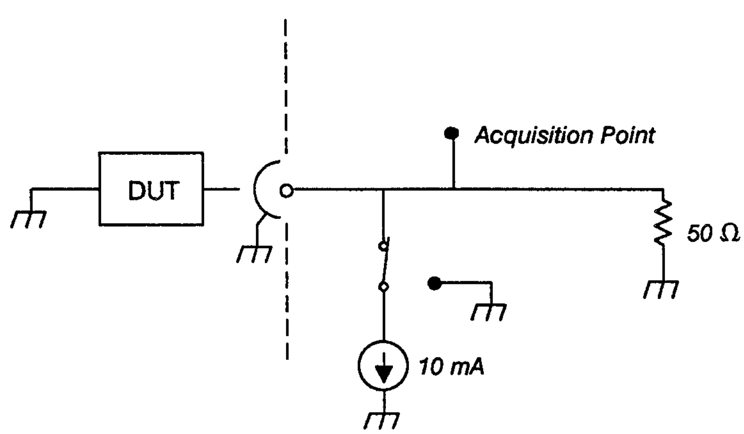
Taking TDR Measurements

This section describes how to use the SD-24 to perform time domain reflectometry (TDR) measurements.

TDR Step Generation

Both channels in the SD-24 TDR/Sampling Head have a step generator, which gives both channels TDR measurement capabilities. You can use the outputs of both generators to perform differential and common mode TDR measurements.

The step generator circuitry consists fundamentally of an adjustable current source and a diode switch. Initially, before the step, the diode switch is biased to conduct current to the output. When the diode switch opens, the step occurs. The following simplified diagram shows the switch and the current source.



Step Generator Simplified Schematic Diagram

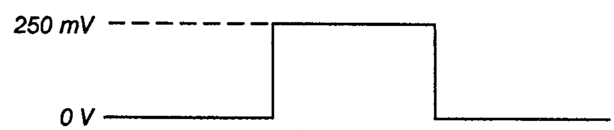
Because of architecture of the step generator, the output voltage of the step depends on the DC resistance to ground of the device under test. The following sections decribe the operation with a short circuit, an open circuit, and a 50 Ω load.

Operation Into a Short Circuit

Initially, the diode switch is conducting −10 mA. When the step generator output is shorted, the resistance to ground is 0 Ω and the output voltage is 0 V.

When the diode switch opens (reverse-biased), apparent resistance to ground at the acquisition point (and at the channel connector) is 25 Ω, because the internal termination resistance is 50 Ω and the connector impedance is 50 Ω. The voltage at the acquisition point rises to +250 mV.

However, as soon as the transition propagates to the short in the device under test, the termination resistance is 0 Ω and the voltage level returns to 0 V. The time displayed from the first transition to the second transition is the propagation time from the acquistion point to the short in the device under test and back.



Step Generator with a Shorted Output